This test covers earthquakes, volcanoes and plate tectonics. I expect it to be quite difficult, as one of the purposes of this test is to make distinctions between those who have studied and those who haven't. So don't panic if you don't know something.

You are allowed a single sheet of resources for this test.

I give partial credit. Try to answer as much of the test as you can.

You may break up the test but if you do so please put your team number on each page so I can reassemble the tests more easily!

Tiebreakers are marked with a T

_____ A: 30 points

_____B: 30 points

_____ C: 20 points

_____D: 10 points

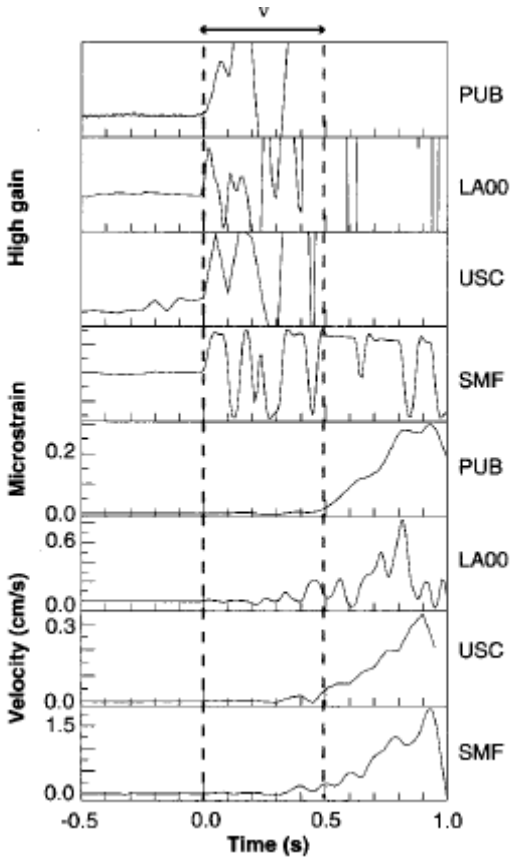
_____E: 10 points

_____Total

Earthquakes (30 points)

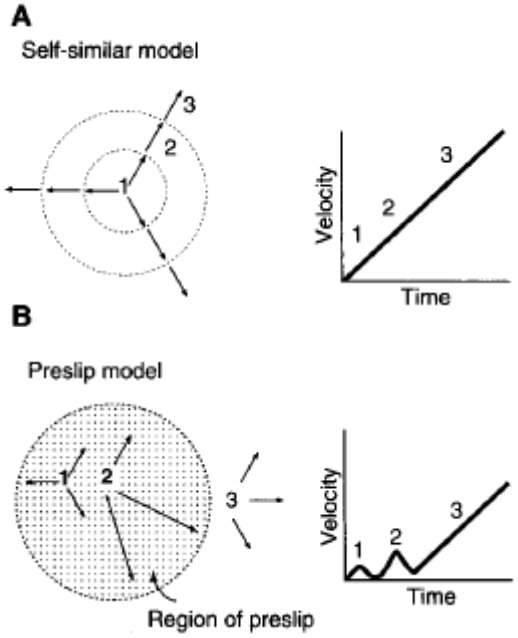
1. The January 17, 1994 Northridge earthquake was the result of the movement of a blind thrust fault. What is a blind thrust fault? (4 points)

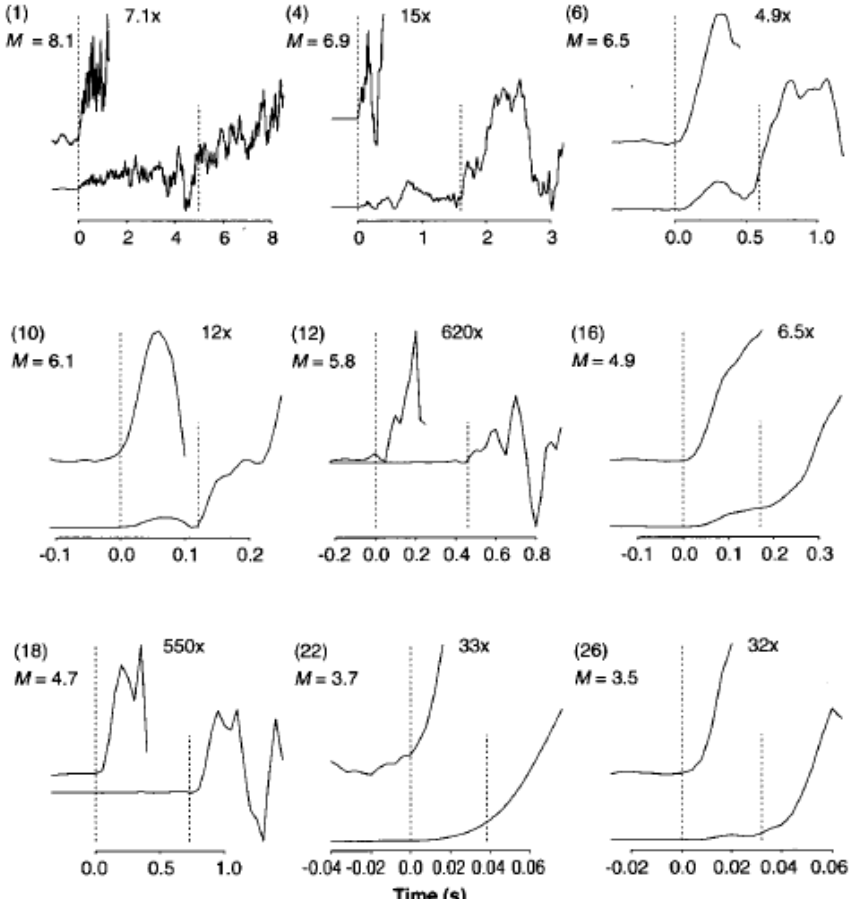
2. Draw a picture, below, of the geometry of such a fault and illustrate the motion along it. (6 points)



3. William Ellsworth and Gregory Beroza (Science, 1995) were interested in how earthquakes like the Northridge earthquake are generated.. The plot at left shows a number of velocity seismographs collected of this earthquake. The top three plots are for "high gain" seismographs, which are magnified to highlight the small scale motions. The bottom plot shows the full range of velocity over the first second of the earthquake. What sorts of waves do these seismographs show, and how do you know? (4 points)

Ellsworth and Beroza were very interested in the pattern of initial motions. They distinguished two phases of an earthquake: a nucleation phase (given by the distance between the dotted lines in the figure on the previous page) and a "breakaway phase". They argued that if the earthquake started as a single event that propagated along a fault, the velocities should rise uniformly as in A. A second hypothesis, as in B at right, is that there is some region that "preslips" and that this serves as a "nucleus" for a region of failure. The earthquake would then start as a region of slow aseismic slip, accelerating until it reached a critical size, at which point the earthquake would go into "breakaway" phase and accelerate over a wide range. They show nine plots below with earthquakes of different *moment magnitudes*.





4. What is the difference between moment magnitude and body wave magnitude? (4 points, T1)

5. Create a plot of moment magnitude vs. nucleation time for these seismographs. Do you find a relationship? Try to explain what you find. (12 points)

Volcanic features (30 points)

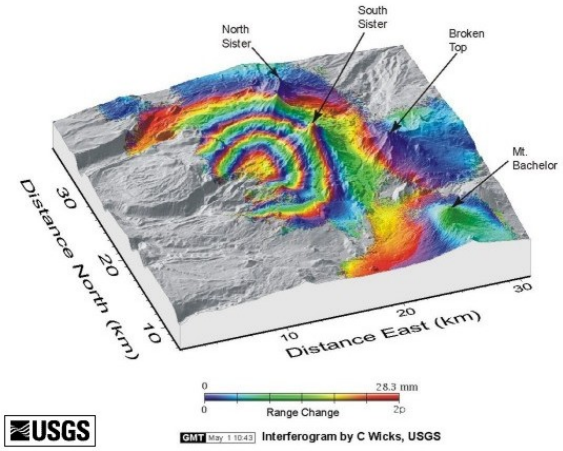
1. What is this volcanic feature called and how is it formed?

2. Is this rock felsic or mafic, and what does that tell you about what kind of eruption is likely to have formed it?

3. What are these rock structures called and how are they formed?

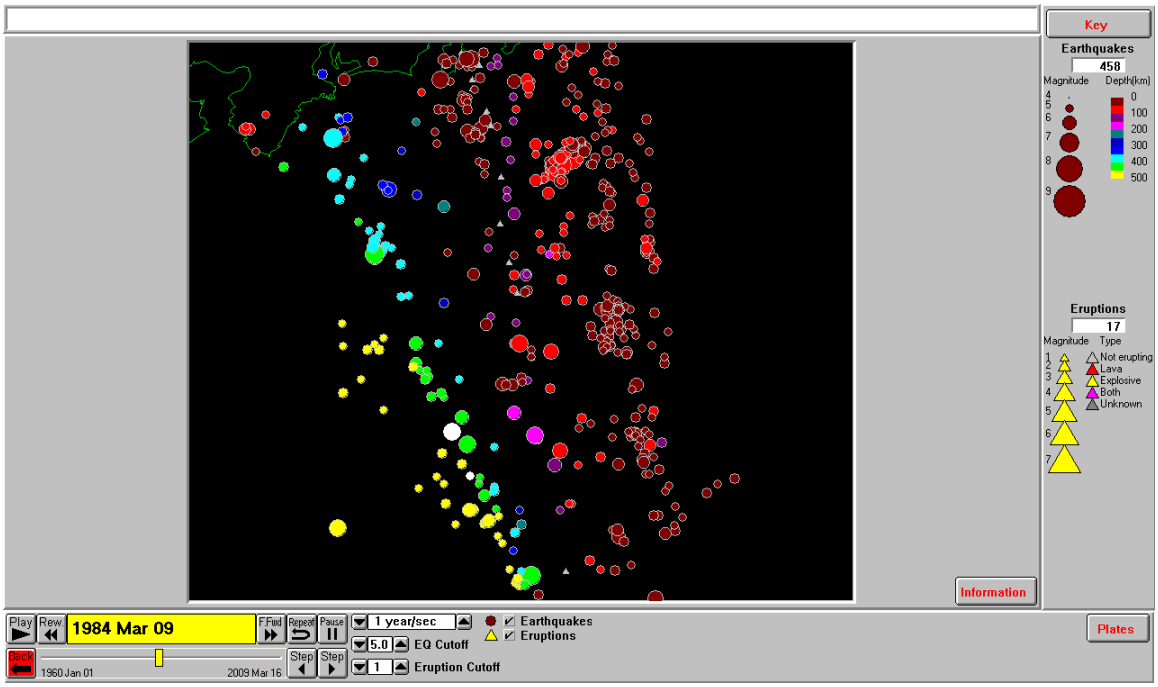
4. Identify the volcanic dike in the picture at left and explain how you know that it is a dike.

5. The image at right is an InSAR image of the Three Sisters Volcanic center in Oregon. How does InSAR tell us about tectonic activity?

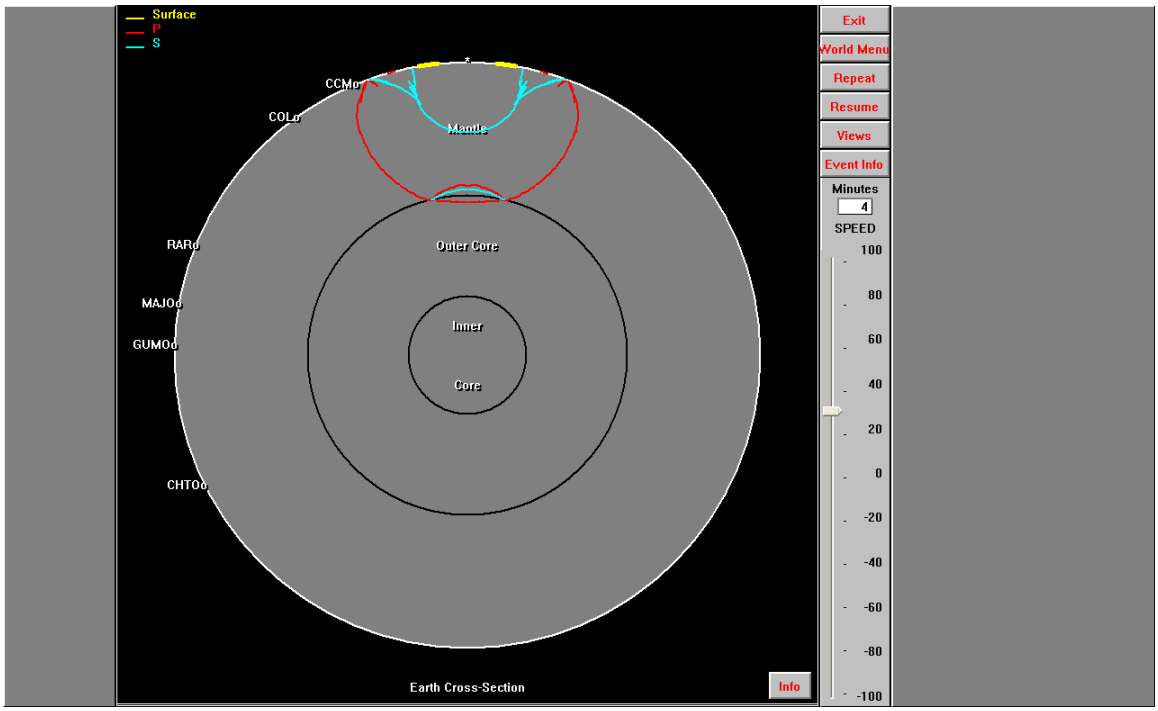


6. The image at left shows the inside of a caldera (the flow of the caldera is below sea level so you can actually sail into it) in the Mediterranean Sea. Some believe that the eruption of this volcano is responsible for the legends of Atlantis. What's the name of the volcano and kind of volcano was it?

C: Seismology and earth structure



The plot above shows a map of the distribution of earthquakes to the south of Japan. The location of the circle show the epicenter, the *size* of the circles shows the magnitude of the quake and the *color* shows the depth of the quake. The (tiny!) gray triangles show a line of volcanoes. Describe the distribution of earthquakes and volcanoes and relate then to what is happening at this plate boundary. (10 points, T2)



Returning to the Northridge quake, above, the lines show wavefronts for P, S and Rayleigh waves.

1. Explain why the outermost red wavefront is not circular. (5 points)

2. Identify the wavefront that will be associated with the PcP wave when it hits the earth surface. (3 points)

3. Will the length of the yellow packet of waves get larger or smaller with time? (2 points)

D. Fill in the blank (1 point each)

1. _____ is an element whose cycle is affected by plate tectonics in a way that helps to stabilize the climate of the earth

2. _____ is a volcanic mineral, formed by deep weathering of rocks, that is a major source of aluminum.

3. The _____ is a seismic discontinuity at the base of the crust where wave speeds rise sharply.

4. _____ rocks are formed deep within the earth.

5. _____ is a phase change of rock which occurs when the pressure is reduced.

6. The primary heat source for mantle convection is _____.

7. The eruption of _____ in 1991 resulted in global cooling lasting more than a year.

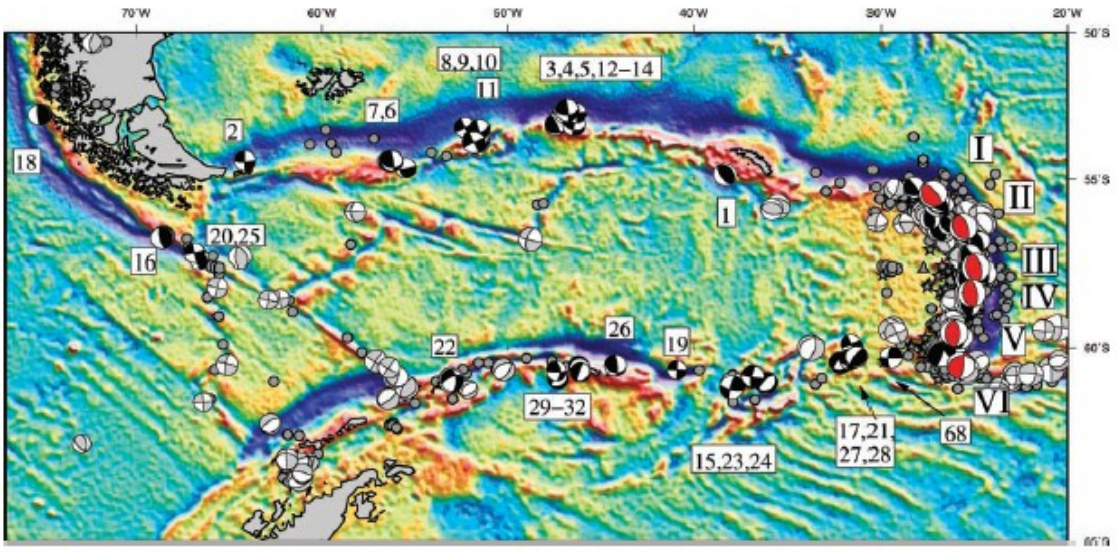
8. Spreading centers create deep valleys (sometimes filled with lakes) known as

_____.

9. The Afar triangle at the end of the Red Sea is an example of a _____.

10. Lines of constant magnetic anomaly run roughly _____.

E. Plates and other features (10 points)



The picture above (from Thomas et al., Geophysical J. Int., 2003) shows a high-resolution picture of the Scotia Arc. The dark blue colors represent deep trenches and the yellows and reds shallower regions. The "beach balls" show the distribution of stress associated with individual earthquakes such that a dark color denotes that the earthquake has result in an increase in stress (compression) and a white denotes that the earthquake has resulted in a decrease in stress (stretching). The red beach balls (I-VI) thus show that the earthquakes along 25W have compression above and below the epicenter and expansion to the east and west, while earthquake 19 shows 4 quadrants, indicating that the earthquake has produce compression to the northwest and southeast and expansion to the northeast and southwest. Using whatever information you can get from this plot, ketch out the plate motion in this region below (7 points). Mark on your sketch where you would expect to find volcanoes (3 points) (T3).